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Transregional Collaborative Research Centre 125

Cognition-guided Surgery

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Div. Medical and Biological Informatics - Germany

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# Cognition Guided Surgery – Projects Overview

## General and Visceral Surgery
- **A01**: Contextually Aware Assistance System for Minimally Invasive Surgery  
  Müller / Speidel
- **A02**: Knowledge-based Navigated Liver Surgery  
  Maier-Hein / Mehrabi

## Cardiac Surgery
- **B01**: Knowledge-based Assistance System for Reconstructive Cardiac Valve Surgery  
  De Simone / Wolf

## Radiation Therapy
- **C01**: Adaptive Photon Therapy in the Treatment of Lung and Liver Tumors  
  Bendl / Combs / Oelfke
- **C02**: Biological and Time Adaptive Therapy of Pancreatic Carcinoma  
  Bendl / Debus / Oelfke

## Platform
- **R01**: Functional Diffusion-Weighted Imaging for Tissue Analysis  
  Klauß / Stietjes / Werner
- **R02**: Innovative Imaging of Tissue Perfusion  
  Grenacher / Stiller / Werner
- **R03**: 4D Imaging of Blood Flow and Movement  
  Beller / von Tengg-Kobligk

## Core Models
- **I01**: Knowledge Modelling and Interpretation  
  Dillmann / Mehrabi / Studer
- **I02**: Knowledge-Based Segmentation  
  Meinzer
- **I03**: Functional Modelling  
  Heuveline
- **I04**: Knowledge-based Multispectral Tissue Analysis  
  Fritzsch
- **I05**: Robotics  
  Müller / Wörm

## Software Infrastructure

**Surgeon’s Dreams**

- Reconstructive Surgery (respect tissue and organs, not resect)
- Assistance (knowledge, mechanical)
- Quantitative Approach (science/teaching)
Vision of B01 in SFB 125 - Knowledge-based assistance system for reconstructive valve surgery

Pre-OP Planning

Intra-OP Decision Making

Post-OP Functional Results

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Mitral Valve Reconstruction – Quantitative Approach

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Mitral Valve Reconstruction – Quantitative Approach

Mitral Valve

Gaudi - Sagrada Familia - Barcelona

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Medical Imaging Interaction Toolkit (MITK)
Dept. of Cardiac Surgery, University of Heidelberg and
Division of Medical and Biological Informatics, DKFZ
Medical Imaging Interaction Toolkit (MITK)
Dept. of Cardiac Surgery, University of Heidelberg and
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**Surgeon’s Dreams**

- Reconstructive Surgery
- Assistance
- **Quantitative Approach (Science/Teaching)**
"To measure is to know"

"If you can not measure it, you can not improve it"

"In physical science the first essential step in the direction of learning is to find methods for measuring some quality connected with it. When you can measure what you are speaking about (and express it in numbers), you know something about it; but when you cannot measure it (when you cannot express it in numbers), your knowledge is of an unsatisfactory kind.

[PLA, vol. 1, "Electrical Units of Measurement", 1883-05-03]

Lord Kelvin (Sir William Thomson)
Intraoperative Valve Analysis
Subjective Visual Assessment of Anatomy by the Surgeon

**Problems:** variability of methods, poor reproducibility, no data to record for learning and teaching purposes

Functional analysis of leaflet segments with nerve hooks

- **Anterior leaflet (sizer)**
- **Posterior leaflet (forceps)**

Mohr-Caliper to measure chordae length
Intraoperative Valve Analysis


Kelly clamp

rigid/flexible metric ruler

calipers

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Computer-Assisted Mitral Valve Analysis (1)

Optical Tracking
Intraoperative system

NDI Polaris

Viewstation

Workstation

Dept. of Cardiac Surgery, University of Heidelberg and Division of Medical and Biological Informatics, DKFZ
Methods: Computer-Assisted Valve Analysis – Optical Tracking
Repeated Measurements on a Rapid Prototyping Heart Model

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Measurements on Swine Hearts

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CT-Scan

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### Geometry of Porcine Hearts – Repeated Measurements (mean ± SD)

<table>
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<tr>
<th></th>
<th>Longitudinal annulus diameter (mm)</th>
<th>Septolateral annulus diameter (mm)</th>
<th>Anterolateral distance PM (mm)</th>
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Matching Ultrasound and Anatomical Measurements

Graser, De Simone et al.; Computer Assisted Annuloplasty – DGTHG 2014 - SJM Award

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Graser, De Simone et al.; Computer Assisted Annuloplasty – DGTHG 2014 - SJM Award
Conclusions

Anatomical parameters tracked by our infrared stereo camera system showed good accuracy and reproducibility.

Computational models allow a more precise quantitative assessment of mitral valve geometry.

Possible advantages of precise intraoperative sizing of anatomy
- guide the surgeon to choose the most suitable reconstruction procedure
- provide a learning tool for training surgeons
- improve outcome of mitral valve repair